Role of Advanced Generation Technologies to Reduce Power Outages

POWER OUTAGES
Harbinger of Things to Come?

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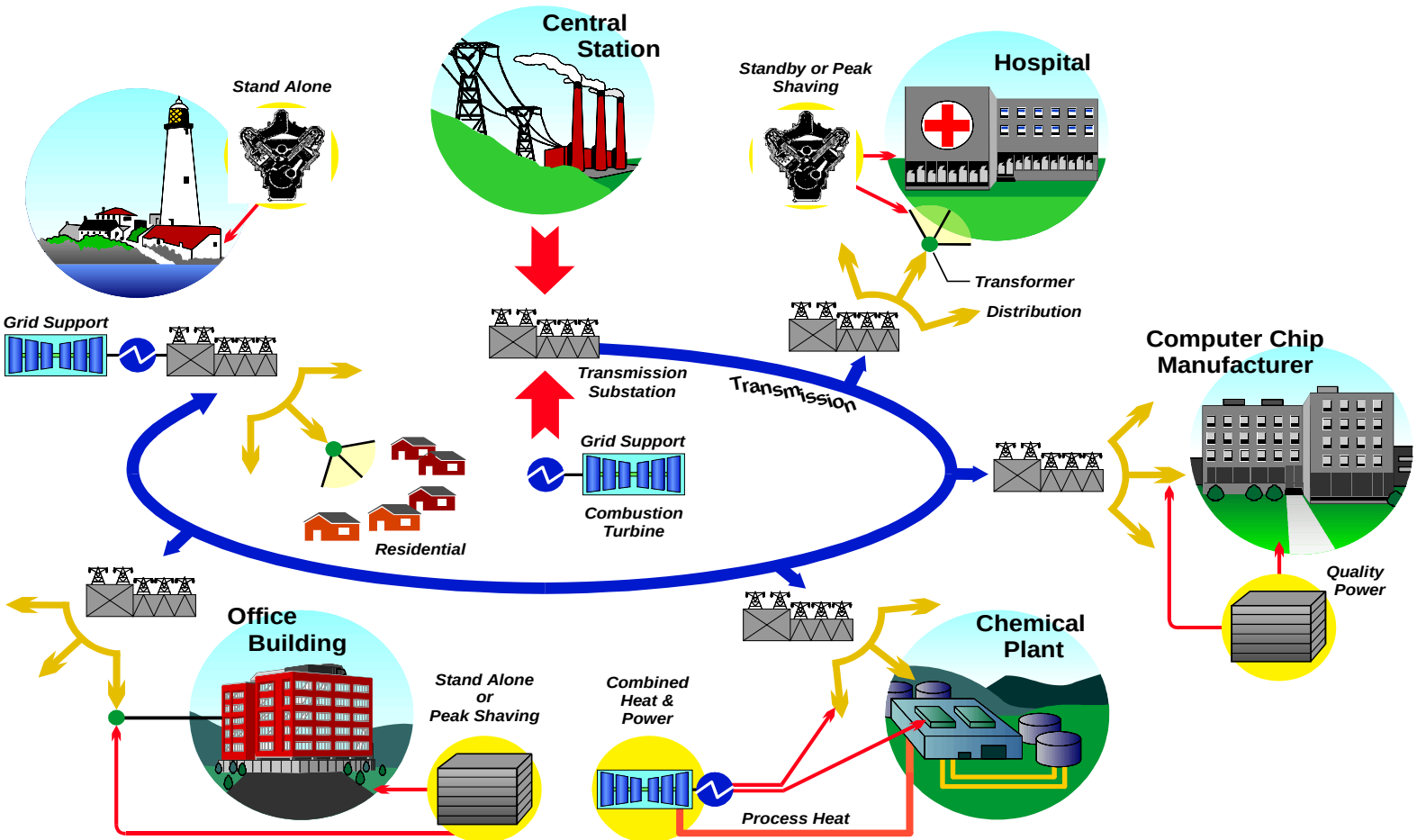
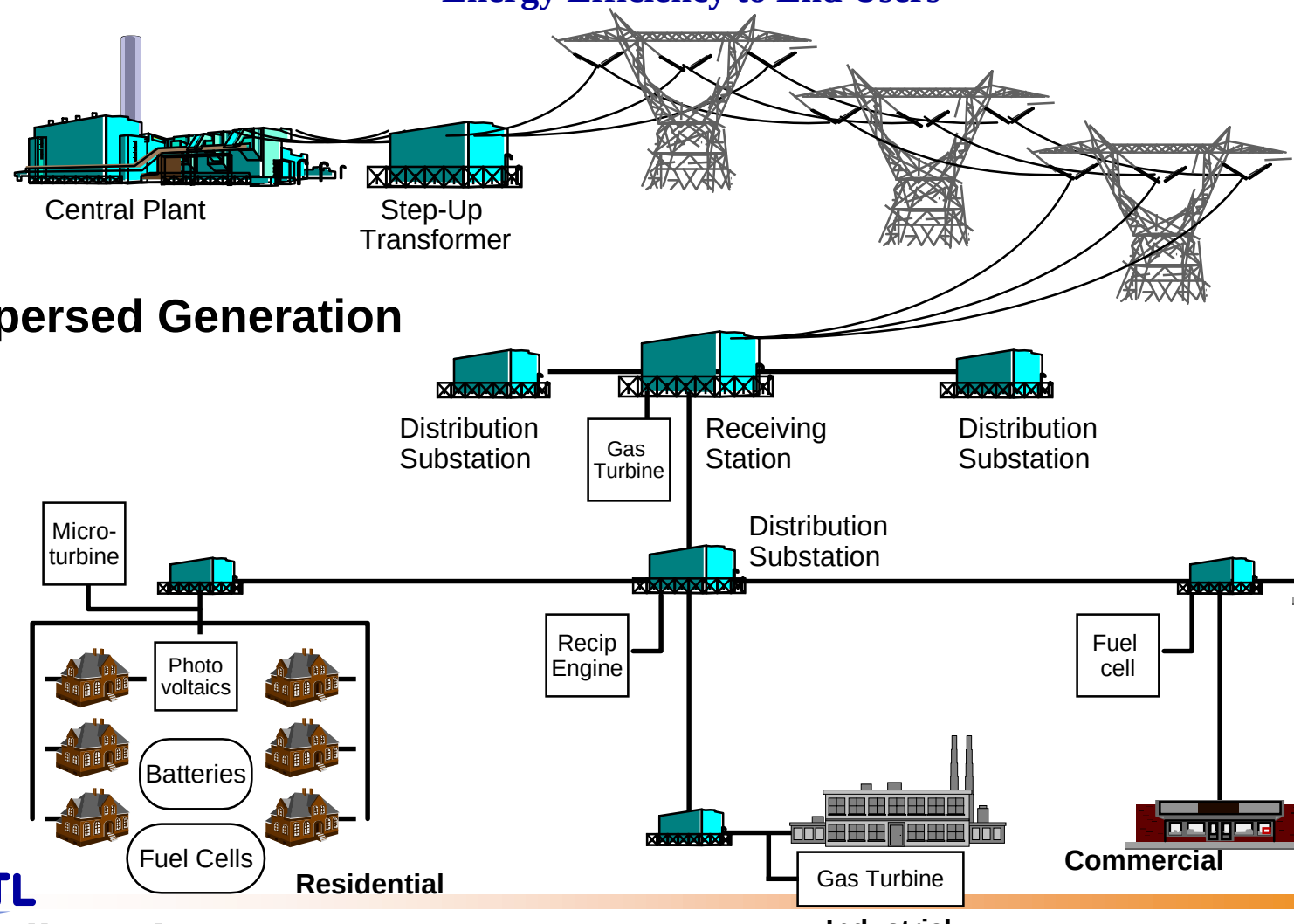
Power Generation Markets of the Future



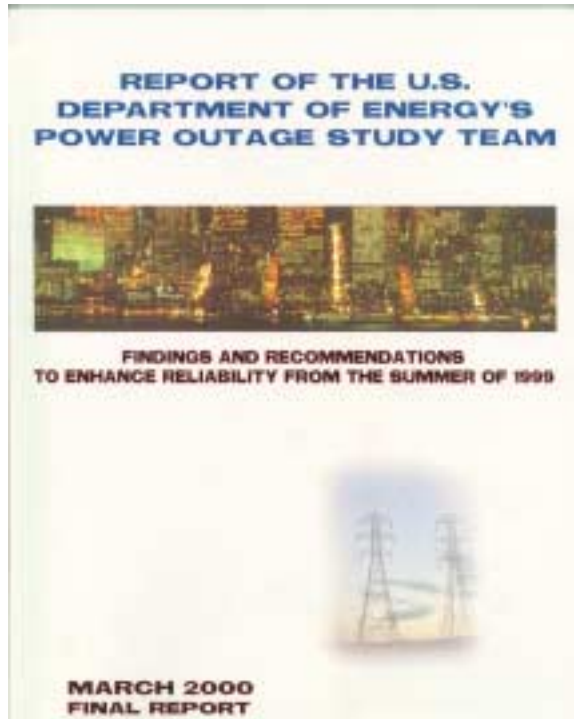
Dispersed and Distributed Resources

1 kW to 100,000 kW Systems Strategically Placed Can Enhance Grid Reliability and Improve Energy Efficiency to End Users



The Past: DOE's Power Outage Study

- Recommended Actions
  - Support the development of interconnection standards for distributed energy resources
  - Integrate customer demand management, distributed generation, and storage technologies
  - Study the potential for using emergency backup generators to reduce system demands to help avoid power outages



The Past: DOE Powering the New Economy

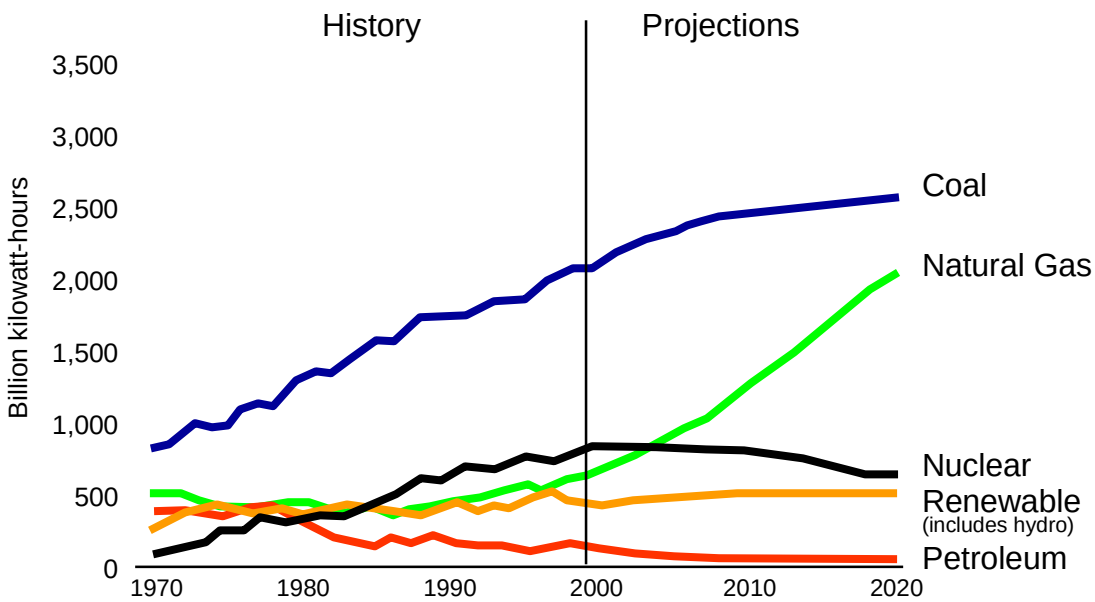
- Federal electricity restructuring
- Investments in the technologies that will enable the inter-grid to operate at higher levels of reliability
- Ensure availability of clean, distributed power technologies and eliminate institutional, business, and technological barrier to their use
- Policies and investments that acknowledge and reflect the increasing interdependence of our electricity and natural gas infrastructure
- Ensure we have adequate supplies of oil and natural gas to meet our near- to mid term power and fuel needs
- Use energy more efficiently and to provide cleaner alternative sources of power and fuel

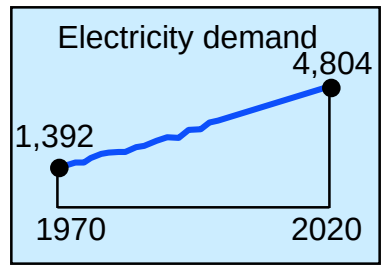
Today: National Energy Strategy

- **President's task force on energy**
- **Address:**
  - how best to cope with high energy prices and reliance of foreign oil
  - how best to encourage the development of pipelines and power generating capacity in the country
  - deal with both short term issues(California) and long term national issues

Electricity Generation by Fuel

DOE/EIA Projects Dramatic Increase in Gas Use





Source: EIA, AEO 2001

Future Solutions?

- **Adequate Supplies -- Power and Fuels**
  - Examples:
    - Advanced Turbine Power Plants
    - Fuel Cells
    - Improved Coal Steam Plants
    - Gas Hydrates
- **Effective Regulations and Policies**
- **Transmission and Infrastructure**

Advanced Generation Has Many Public Policy Benefits

Electric Reliability

Lower Costs

Environmental Performance

U.S. Competitiveness

Mission

Foster a secure and reliable energy system that is environmentally and economically sustainable

DOE Power Program Addressing Issues

- **Office of Energy Efficiency and Renewable Energy**
  - Distributed Energy Resources
  - Electric Infrastructure Reliability
- **Office of Fossil Energy**
  - **Coal**
    - Power Plant Improvement Initiative
    - Vision 21(also includes gas/coal focused)
  - **Strategic Center for Natural Gas**
    - Next Generation Turbine Program
    - Fuel Cells/SECA
    - Natural Gas Infrastructure
    - Supply and Storage

ATS Program Objectives

By 2000, develop advanced turbines that are:

- **Ultra-high efficiency:** >60% for utility-scale systems
  15% improvement for industrial- scale systems
- **Super-clean:** NOx <10 ppm
- **Cost of electricity:** 10% less
- **Fuel-flexible:** gas is primary focus

Leapfrog in Turbine Performance

Advanced Turbine Systems *System Development and Testing*

- **ATS utility scale products are the cleanest, most efficient gas turbine power plants in the world**
- **Scheduled for demonstration near Scriba, New York and Orlando Florida during the year 2002**
- **Over 95 universities, DOE national labs and US industries partnered to develop ATS**

Small Combustion Turbines

1992

- 28% efficiency
- Double-digit ppm NO_x

- *Advanced designs*
- *Lower cost operations*
- *Improved RAMD*

2000

- 40% efficiency (simple cycle)
- Single-digit ppm NO_x
- 3.5 cents/kWh (8,000 hrs/yr)

Microturbines

2000

- 21-33% efficiency
- 25-300 kW
- Commercially available
- Few moving parts

- *Advanced materials*
- *Improved recuperators*
- *Low emission combustors*

2010

- 50% efficiency
- Single-digit ppm NO_X
- 25 kW - 1 MW

Phosphoric Acid Fuel Cells

1993

- "Commercially ready"

2000

- 204 units
- 40% efficiency
- $4,500/kW
- 200 kW
- Plug and play

DoD cost-shared in 3/4 of units

PEM Fuel Cells for Buildings

2000

- **Field tests**
- **Intense market interest**

2002-2005

- **Commercial availability**
- **Cost reductions**
- **40% efficiency**
- **$1,500/kW**
- **1 - 75 kW**

– ***Commercial***
– ***Residential***

Molten Carbonate Fuel Cells

2000

- Demonstration
- 47% efficiency
- $8,000/kW
- 250 kW
- Internal reforming

2003-2008

- Near-term DG market
- 50-60% efficiency
- $1,000-1,500/kW
- 250 kW - 3 MW

Solid Oxide Fuel Cells

2000

- 47% efficiency
- > $10,000/kW
- 100 - 220 kW
- Internal/coupled reforming

2003-2008

- Near-term DG market
- 47-63% efficiency
- $1,000-1,500/kW
- 250 kW - 1 MW

Fuel Cell/Turbine Hybrids

2000

- > $10,000/kW
- 57-59% efficiency
- 220 kW

2004-2010

- DG market
- $1,000-1,200/kW
- 70% efficiency
- 1 - 20 MW

SECA Development: Progressive Applications

2003-2005

- Prototype testing
- $800/kW
- Auxiliary power
- Residential

2010

- $400/kW stationary units
- $200/kW vehicles/reformer

2015

- 75% efficient plants
- $50/kW propulsion

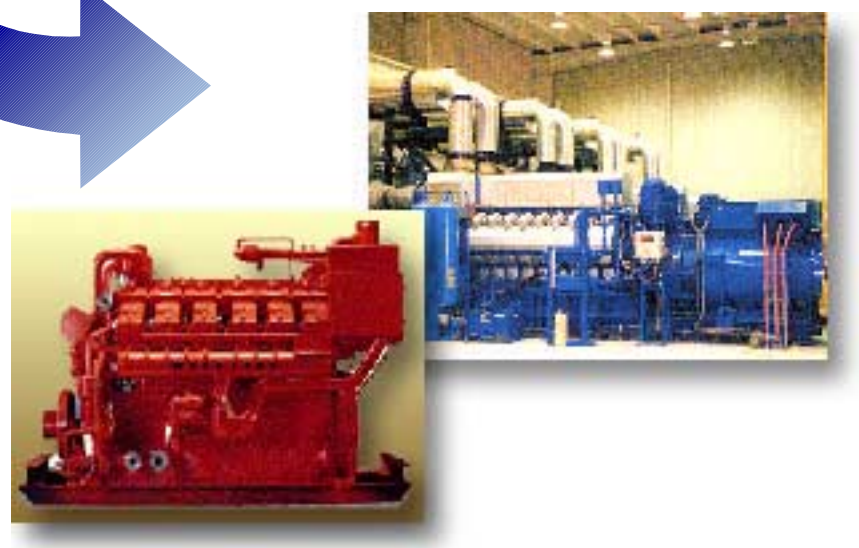
Natural Gas Engines

2000

- < 40% efficiency
- > 50 ppm NO_x
- $200-800/kW
- < 5 MW

2010

- 50% efficiency
- 5 ppm NO_x



Working to Overcome Barriers

- Cost
- Awareness
- IEEE 1547 Interconnection Standard
- Net metering
- Streamlined siting and permitting process
- Output-based emission standards

Gas Infrastructure Reliability

- **Infrastructure includes:**
  - Transmission systems
  - Distribution systems
  - Gas storage

- **Program goals**
  - Enhance safety and reli
  - Increase gas deliverabi
  - Reduce environmental impact

Natural Gas Exploration and Production

- **Near-term: recover more from known fields**
- **Mid-term: unlock low perm resources containing natural fractures**
- **Long-term: encourage exploration for deep gas and hydrates**

Developing Technologies to Ensure an Abundant, Economical Supply of Natural Gas With Minimal Environmental Impact